

Final Report

Experimental Equipment Design and Fabrication Study for Delta-G  
Experiment

NASA/MSFC RFQ No. 8-7-EA-12588

UAH Proposal 97-422

The Research Machine Shop at UAH did not develop any new technology in the performance of the following tasks.

All tasks were performed as specified, the final products delivered to Mr. Ron Koczor at NASA. Final products were in the form of a crucible with manipulating fixturized hardware to facilitate pouring liquid ceramic materials at 1200 degrees Centigrade for Task #1, a single phone number and identification of location of the requested power supply for Task #2, and a filament-wound carbon composite fiber applied to the periphery of ceramic superconducting materials to improve structural integrity when subjected to high levels of rotational g-forces for Task #3.

#### Scope of Work:

Task 1: UAH RMS shall design and fabricate a "proof" model of a silicon-carbide high-temperature crucible with dimensions of 8 inches in diameter and 4 inches in depth. This crucible shall be suitable for pouring liquid ceramic materials at 1200degrees Centigrade into molds from heating ovens. The crucible shall also be designed with a manipulation fixture to facilitate holding and pouring of the heated liquid material.

Task 2: UAH RMS shall investigate the availability of 400Hz, high-current (65 volts @ 100 ampheres) powere systems for use in high-speed rotating disk experiments.

Task 3: UAH RMS shall investigate, develop a methodology, and experiment on the application of filament-wound carbon fibers to the periphery of ceramic superconductors to withstand high levels of rotational g-forces. UAH RMS shall provide analytical data to verify the resulting improved structural integrity of the YBCO disc with carbon composite fibers. (Report Attached)

Materials:

		\$200.00
1	Silicone Carbide Mixture	90.00
2	Stainless Steel, rod, bar & other shapes	150.00
3	Carbon Composite fiber material	100.00
4	Crucible Mold materials	110.00
5	Cutting tools, Silicone Carbide qualified	75.00
6	Mold form material, cc fiber aluminum	45.00
7	Epoxy adhesive filler	213.00
8	Stainless Steel clamping assemblies	200.00
9	Fasteners, assorted, stainless	

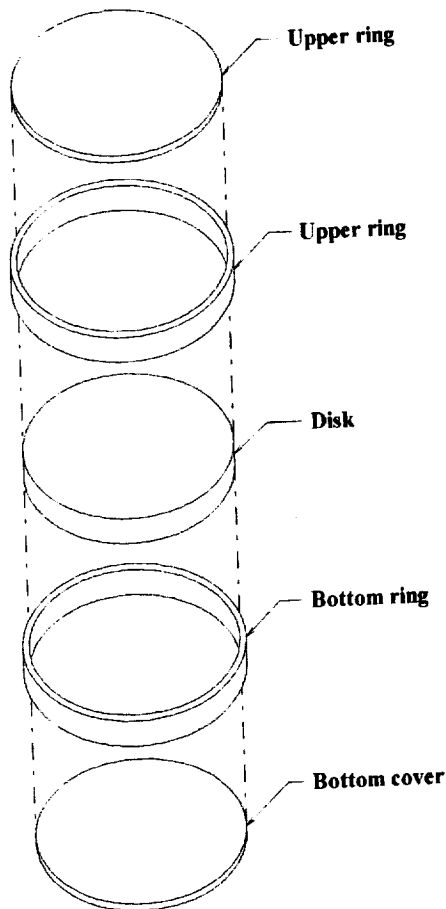
Manpower:

A total of 166 hours were utilized in the performance of the above listed tasks.

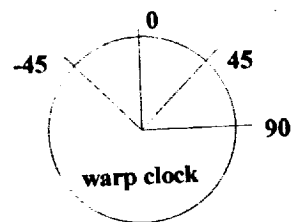
# MANUFACTURE OF GRAPHITE/EPOXY COVER FOR SUPERCONDUCTOR DISK

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9-2-97

Two graphite/epoxy rings and two graphite/epoxy cover plates were constructed in the Composites Lab At UAH. The parts are intended to help support and contain a superconducting disk during operation at cryogenic temperatures.



The lay-up schedule for rings consisted of a (0,0,0,0,90,0,0,0,0,90/90,0,0,0,0,90,0,0,0,0) stacking sequence. The cover plates were stacked with a (0,45,90,-45,0,45,90,-45,0,90/90,0,-45,90,45,0,-45,90,45,0) lay-up schedule. The parts were constructed from IM6G/3501-6 graphite/epoxy unidirectional tape, and cured in a 350° F oven for two hours while maintaining a 25 inch Hg vacuum pressure.



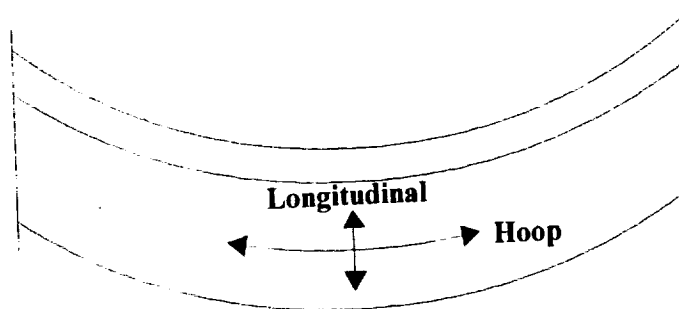
The tensile strength of the gr/ep material is given as 290 Ksi. This value was determined from tensile tests of 4 and 6 ply unidirectional laminates conducted and tested at an earlier date. With this value, using a weighted area estimation for strength, the hoop strength of the ring will be approximately 232 Ksi. Using the same approach the longitudinal strength will be approximately 58 Ksi.

$$\sigma_h = (A_{0^\circ}/A_T) * \sigma_{0^\circ} = [(16 * 0.006) * W] / [(20 * 0.006) * W] * 290 = 232 \text{ Ksi}$$

$$\sigma_l = (A_{90^\circ}/A_T) * \sigma_{0^\circ} = [(4 * 0.006) * W] / [(20 * 0.006) * W] * 290 = 58 \text{ Ksi}$$

[Assuming  $\sigma_{\text{fiber}} \gg \sigma_{\text{resin}}$ ]

$T$  = Number of Plies \* thickness of each ply = Overall ring thickness  
Ply thickness (Nominal) = 0.006 inch  
 $W$  = Width of ring  
 $A = W * T$  = Cross sectional area



The procedure followed for the making the rings include:

1. Mold preparation; Three coats of Freecote release agent.
2. Continuous Wrap 4 plies of  $0^\circ$  tape.
3. Wrap 1 ply of  $90^\circ$  tape (Stage A  $[0,0,0,0,90]$ ).
4. Debulk by vacuum bagging laminate for 10 minutes.
5. Rotate starting point 90 degrees and repeat steps 2 and 3 (Stage B  $[0,0,0,0,90]$ ) and add one additional  $90^\circ$  ply.
6. Debulk by vacuum bagging laminate for 10 minutes.
7. Rotate starting point 90 degrees and repeat steps 2 through 4 (Stage C  $[90,0,0,0,0]$ ).
8. Finish laminate with 4 plies of 0 tape (Stage D  $[90,0,0,0,0]$ ).
9. Debulk for 10 minutes.
10. Position outer mold segments evenly around laminate and compress with hose clamp. Loosen and reposition clamp as needed to ensure uniform compression of segments.
11. Wrap mold and laminate in several layers of peel ply and place in a vacuum bag.
12. Pull a vacuum on part (25 in Hg) and place in oven set to  $350^\circ\text{F}$  for 2 hours.
13. After cure is completed, let part cool to  $200^\circ\text{F}$ , then remove from vacuum bag and debur edges.

Procedure for making top and bottom caps:

1. Mold preparation; Three coats of Freecote release agent.
2. Stack material according to lay-up schedule
3. Cover laminate with peel ply.
4. Pull a vacuum on part (25 in Hg) and place in oven set to 350°F for 2 hours.
5. After cure is completed, let part cool to 200°F, then remove from vacuum bag and debur edges.

Notes:

The added ring and cover plates will provide an additional resistance to disk failure due to centrifugal forces by approximately 232 Ksi. The longitudinal strength of the ring (58 Ksi) will provide resistance to separation of the ring's hoop fibers in the event that the disk begins to split. The longitudinal fibers will also serve to transfer the loads from the cover plates across the width of the disk.

Analysis of the adhesive joint bonding the cover plates to the upper and lower rings as well as the two rings together will determine the ultimate strength for this structure. Since these joints have relatively small surface area and none of the high strength graphite fiber cross the joint, the bond quality of the adhesive will drive the ultimate survivability of the structure.

If it is determined that the adhesive joint is inadequate it may be possible to filament wind a cover/ring assembly in one step. Depending upon whether or not the disk can handle a 350 F cure, it may be possible to wrap directly over the disk with a prepreg graphite/epoxy, as was used for the present part, or if the high temperature cure is not allowed a room temperature cure with a wet wound resin would be an alternative. Another option would be to make a split ring with integral covers formed either by filament winding or in a multiple piece mold, similar to the one used to make the existing parts.